



## New Partial Oxidation Catalysts for Liquid Fuel Reforming in Fuel Cell Systems

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# Transportation

## FOR THE 21ST CENTURY

### Background

A fuel cell produces electricity directly from the electrochemical reaction of hydrogen, from a hydrogen-containing fuel, and oxygen from the air. While gaseous hydrogen is the ideal fuel for a fuel cell, the infrastructure for producing, storing, and delivering hydrogen does not yet exist. To develop a viable hydrogen infrastructure for transportation, significant capital investments will have to be made. While such a fundamental restructuring of the nation's transportation fuel base may take place in the future, for the near-term, conventional fuels will continue to play a dominant role in ensuring America's mobility.

Researchers at Argonne National Laboratory (ANL) have developed and patented a new family of reforming catalysts that will allow fuel-cell-powered cars to run on conventional fuels. The new catalysts will be used in the on-board fuel processor (reformer) of an automotive fuel cell system to convert gasoline, or other hydrocarbon fuels, into hydrogen-rich gas. This reforming catalyst, an enabling technology for fuel cell systems, will allow fuel cell vehicles, which produce near-zero emissions, to operate on widely available conventional fuels. In recognition of this achievement, six researchers at ANL received the prestigious R&D 100 Award for 2001 from *R&D Magazine*.

### The Technology

Autothermal reforming (ATR) of natural gas and other hydrocarbon fuels to hydrogen, carbon monoxide, and carbon dioxide is commonly carried out on an industrial scale at about 1000°C in the chemical process industry. However, the size, weight, and cost constraints imposed on on-board fuel processors for automotive applications meant that a new approach had to be investigated. ANL's Chemical Technology Division began exploring the catalytic conversion of liquid fuel to hydrogen for fuel cell systems in the late 1980s. This effort involved high-risk basic research and presented enormous difficulty in identifying the correct

catalyst. Also, since the reactions involve complex hydrocarbons, the catalysts must be kept clean with copious amounts of steam to keep them from fouling. Reducing or eliminating the need to store water on board was essential to making this process practical for automotive use.

The Argonne team eventually uncovered a class of new materials that support the partial oxidation chemistry necessary for the conversion of gasoline and other liquid hydrocarbon fuels to hydrogen gas at relatively low temperatures and with low steam requirements. The lower temperatures also enabled the use of inexpensive materials of construction. The new catalysts may contain either noble metals or non-noble transition metals bonded to an oxide ion conductor substrate, such as zirconia, ceria, or lanthanum gallate. Experiments have shown that some of the non-noble metals, such as nickel, copper, iron, and cobalt, when bonded to this substrate, are as active as the more expensive noble metals, platinum and palladium, at temperatures as low as 700°C. The platinum-containing catalysts have, however, demonstrated excellent resistance to sulfur, a contaminant that may be present in fossil fuels. Tests at Argonne using an engineering-scale processor incorporating these catalysts have demonstrated high quality hydrogen production – a major step towards the realization of commercially viable, fuel-cell-powered automobiles.

### Commercialization

ANL and Süd-Chemie, Inc. (formerly United Catalysts) of Louisville, Kentucky, have signed a licensing agreement under which Süd-Chemie will manufacture and distribute the new catalysts. Süd-Chemie has successfully scaled up production and supplied numerous sample quantities for testing in both automotive and stationary fuel cell applications. Süd-Chemie has been the leading developer and manufacturer of catalysts for the production of hydrogen from hydrocarbons for more than 50 years and plans to be a major supplier of catalysts used in fuel processors for fuel cell systems.

### Benefits

- Converts conventional fuels, such as gasoline, to hydrogen for use in fuel cells
- Reduces the temperature required for hydrocarbon reforming by hundreds of degrees
- Platinum catalyst is resistant to fuel contaminants, such as sulfur



*The new reforming catalysts will allow fuel cell vehicles to operate on widely available conventional fuels.*

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